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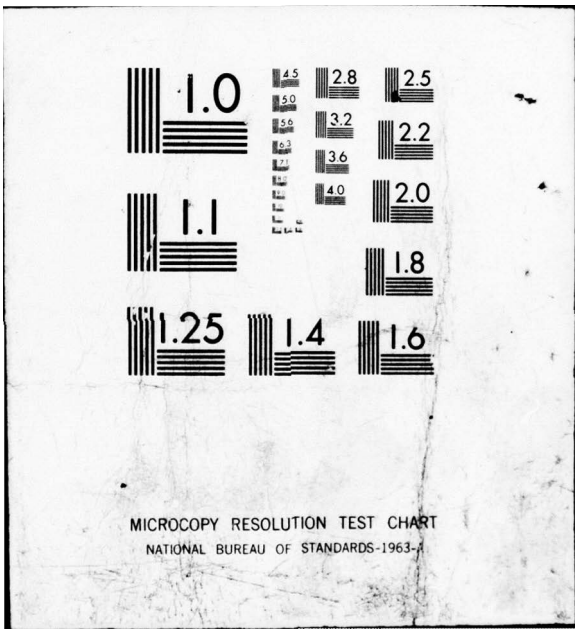
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DESTROYER ENGINEERED OPERATING CYCLE (DDEOC)

System Maintenance Analysis

FF-1052 CLASS ASROC MISSILE HEATING AND COOLING SYSTEM AND RADAR-SONAR ELECTRONIC FRESH WATER COOLING SYSTEM

SMA 218-728

REVIEW OF EXPERIENCE

September 1977

Prepared for
Director, Escort and Cruiser
Ship Logistic Division
Naval Sea Systems Command
Washington, D. C.
under Contract N00024-76-C-4319

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This report, the Review of Experience, documents the historical maintenance experience for two FF-1052 Class systems -- the ASROC Missile Heating and Cooling System and the Radar-Sonar Electronic Fresh Water Cooling System.

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SYSTEM MAINTENANCE ANALYSIS
FF-1052 CLASS

ASROC MISSILE HEATING AND COOLING SYSTEM
AND
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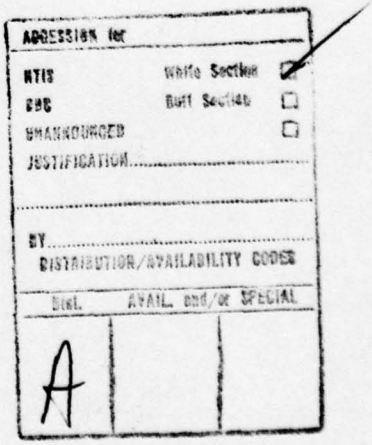
FOREWORD

This report, the Review of Experience, documents the historical maintenance experience for two FF-1052 Class systems -- the ASROC Missile Heating and Cooling System and the Radar-Sonar Electronic Fresh Water Cooling System. The report has been developed for NAVSEA 934X, the sponsor of the Destroyer Engineered Operating Cycle (DDEOC) Program, under Navy Contract N00024-76-C-4319.



SUMMARY

The goal of the Destroyer Engineered Operating Cycle (DDEOC) Program is to effect an early improvement in the material condition of ships, at an acceptable cost, while maintaining or increasing their operational availability during an extended operating cycle. In support of this goal, System Maintenance Analyses (SMAs) are being conducted for selected systems and subsystems of designated surface combatants. The principal element of an SMA is the Review of Experience (ROE). This report documents the ROE for two FF-1052 Class systems -- the ASROC Missile Heating and Cooling System and the Radar-Sonar Electronic Fresh Water Cooling System.

The ROE is an analysis of existing and anticipated problems that affect the operational performance or maintenance program of a ship system. The ROE report serves as a vehicle for assessing the significance and consequences of identified problems. It also presents specific recommendations and a system maintenance policy for preventing or reducing the impact of problem occurrence, while improving material condition and maintaining or increasing system availability throughout an extended operating cycle.

In the ROE for the ASROC Missile Heating and Cooling System and the Radar-Sonar Electronic Fresh Water Cooling System, maintenance data from all available sources were analyzed. The documented maintenance experience of the systems was reviewed through analysis of Maintenance Data System (MDS) data, Casualty Reports (CASREPTs), and system overhaul records. Initial findings from these sources were correlated with Planned Maintenance System (PMS) requirements, system alterations, and system technical manuals to identify maintenance problems. Ship surveys were conducted and discussions were held with appropriate technical codes to validate identified problem areas, identify undocumented maintenance problems, and determine the status of current and planned actions affecting the two systems under investigation. All findings were evaluated and appropriate conclusions developed. The conclusions then became the basis for recommendations to implement existing and newly defined corrective actions directed toward minimizing the occurrence of identified problems and their impact on the extended operating cycle.

The major findings and conclusions resulting from the Review of Experience are as follows:

- The FF-1052 Class ASROC Missile Heating and Cooling System and Radar-Sonar Electronic Fresh Water Cooling System have not been major contributors to the overall ship maintenance burden.
- Major restorative maintenance should not be required on these systems during the extended operating cycle.
- Reduced system capability has not been frequent or severe; down-time resulting from the few reported failures has not been significant.
- A "run-to-failure" maintenance strategy for system pumps during the period between BOH and ROH appears feasible.
- Past practice has generally been to overhaul the heat exchangers and clean, flush, and test the complete systems during each Regular Overhaul (ROH). Additional overhauls or repairs to pumps, motors, and other system components have been based on results of pre-ROH tests and inspections or on the current ship's maintenance project (CSMP).
- The Mixed-Bed Cartridge, NSN 9C4610-00-712-9394, is not listed on Demineralizer APLs 080150006 and 081080004 as an allowed on-board spare.

Six recommendations resulted from the analysis:

- Cyclic open-and-inspect PMS requirements for system pumps should be deleted.
- Adopt a "run-to-failure" maintenance strategy for system pumps during the period between BOH and ROH.
- Material Condition Assessment criteria and performance monitoring techniques should be developed for the pumps of the ASROC Missile Heating and Cooling System and Radar-Sonar Electronic Fresh Water Cooling System to permit a shift from "run-to-failure" maintenance to "on condition" maintenance.
- The heat exchangers of the ASROC Missile Heating and Cooling System and the Radar-Sonar Fresh Water Cooling System should be overhauled and the entire systems cleaned, flushed, and tested during Baseline Overhaul (BOH). Determination of the need for pump and motor overhauls or repairs should be based on the results of pre-BOH tests and inspections and ship's CSMP.
- Ship's Force personnel, supported by an Intermediate Maintenance Activity as necessary, should perform all required corrective maintenance during the operating cycle. System repair required during the follow-on ROH should be determined on the basis of pre-ROH inspections and tests and ship's CSMP.

- Ships Allowance List should be updated to include the Mixed-Bed Cartridge, NSN 9C4610-00-712-9394, as an allowed on-board spare -- 2 each for component APL 080150006 for ship classes FF-1052 through 1077 and 2 each for component APL 081080004 for ship classes FF-1078 through 1097.

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CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND

In support of the Destroyer Engineering Operating Cycle (DDEOC) Program sponsored by NAVSEA 934X, System Maintenance Analyses (SMAs) are being conducted on selected systems and subsystems of program-designated surface combatants. The principal element of an SMA is the Review of Experience (ROE). This report documents the ROE for two FF-1052 Class systems -- the ASROC Missile Heating and Cooling System and the Radar-Sonar Electronic Fresh Water Cooling System -- which were selected for analysis because the Missile Heating and Cooling System is on the FF-1052 Class Maintenance Critical Equipment List.

1.2 PURPOSE AND SCOPE

The ROE is an analysis of existing and anticipated problems that affect the operational performance or maintenance program of a ship system. The ROE report serves as a vehicle for assessing the significance and consequences of identified problems. It also presents specific recommendations and a system maintenance policy directed toward preventing or reducing the impact of problem occurrence while improving material condition and maintaining or increasing system availability throughout an extended ship operating cycle.

The analysis of the ASROC Missile Heating and Cooling System and the Radar-Sonar Electronic Fresh Water Cooling System was concerned with only those system components that had been installed or were on board ship as of the fourth quarter of Fiscal Year 1976. A listing of the major components considered is provided in Appendix A.

The analysis used all available documented data from which system maintenance problems could be identified and studied. Such data were obtained from the Maintenance Data System (MDS), Casualty Reports (CASREPTs), system overhaul records, Planned Maintenance System (PMS) requirements information, system alteration documentation, and system technical manuals. Undocumented data employed in this analysis were obtained from discussions with Ship's Force and other cognizant technical personnel.

1.3 SYSTEM FUNCTIONS AND BOUNDARIES

1.3.1 ASROC Missile Heating and Cooling System

The FF-1052 Class ASROC Missile Heating and Cooling System maintains the temperature in the ASROC launcher within the limits necessary to protect the ASROC missile and propellant grain from wide temperature excursions experienced as a result of seasonal and geographical changes. The physical boundary at the train ring of the launcher separates the Missile Heating and Cooling System addressed in this report from the launcher, which is the subject of a separate report*. The major components of the Missile Heating and Cooling System are the fluid compression tank, fluid heater, fluid cooler, fluid system pumps, and motors.

1.3.2 Radar-Sonar Electronic Fresh Water Cooling System

The FF-1052 Class Radar-Sonar Electronic Fresh Water Cooling System maintains the temperature within the limits necessary to protect water-cooled units of the Radar and Sonar Systems from overheating. In the details of its configuration, this cooling system varies from ship to ship because of the general shipyard practice of tailoring any cooling system to match the physical layout of the particular ship under construction. On the FF-1052 Class ships however, the Radar-Sonar Cooling System configuration was consistent in the major components, i.e., pumps, motors, coolers, and demineralizers. Strainer and valve populations of the Cooling System varied widely, although some correlation was observed between ships built by the same shipyard.

1.4 REPORT FORMAT

The remaining chapters of this report describe the analysis approach utilized (Chapter Two), briefly define significant system maintenance history (Chapter Three), and summarize conclusions and recommendations derived from the analysis (Chapter Four). Specific analyses and evaluations supporting the findings of this effort are included as appendixes to this report. A list of references precedes the appendixes.

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*ARINC Research Corporation, *Destroyer Engineered Operating Cycle (DDEOC), System Maintenance Analysis, FF-1052 Class ASROC Launching Group, Review of Experience*, October 1976, Publication 1645-50-4-1550.

CHAPTER TWO

APPROACH

2.1 OVERVIEW

This chapter describes the approach to the performance of the ROE for the ASROC Missile Heating and Cooling System and the Radar-Sonar Electronic Fresh Water Cooling System.

The analysis was initiated at the component level at which Allowance Parts Lists (APL) numbers are assigned. Major steps of the analysis were as follows:

- Compilation of documented and undocumented maintenance history data from the sources listed in Chapter One, Section 1.2
- Analysis of the data to identify and define maintenance problems that will have significant impact on the maintenance program of the two systems during the DDEOC
- Detailed problem analysis and definition of alternative solutions for the purpose of recommending a specific course of action relative to the maintenance program

These activities are described in Sections 2.2, 2.3, and 2.4.

2.2 DATA COMPILATION

The analysis began with the compilation of a comprehensive data base on the maintenance history of the systems. The data file consisted of four key elements: an MDS data bank, a CASREPT narrative summary, a system overhaul experience summary, and a system ShipAlt summary. A library of appropriate technical manuals, bulletins, and related documents was also assembled. The MDS data bank was compiled by examination of all MDS data reported for the FF-1052 Class from 1 January 1970 through 31 October 1976. CASREPT information covering the period 1 July 1973 through 30 June 1976 was reviewed. Overhaul information was obtained from authorized Ship Alteration and Repair Plans (SARPs) for the FF-1052 Class.

2.3 MAINTENANCE PROBLEM DEFINITION

Potential maintenance problems associated with the systems and their components were identified by a screening process employing data obtained from the above-described sources as well as from ship surveys, discussions with Navy technical personnel, and, when appropriate, NAVSEA special-interest items.

MDS data constituted the initial and primary source of information used in the screening process. This data base includes all part and labor records, as well as narrative material, describing maintenance actions reported against system components. Maintenance actions are represented by Job Control Numbers (JCN). The purpose of the first step in the screening process was to identify the maintenance actions that had been reported against components of the two systems under investigation.

Computer-assisted analysis was next employed to quantify the man-hour and part-expenditure burdens incurred for each component. Individual components or component classes which had contributed significantly to the system's maintenance burden were selected for the analysis. Components were also selected for this purpose if they had generated a significant number of CASREPTs or if other sources of information (e.g., ship surveys or overhaul experience) disclosed significant concern regarding maintenance problems or the maintenance programs for the components.

Detailed analysis of the selected components was directed toward defining each maintenance problem in terms of several specific factors. These were: the effect of the problem on the component and system; the interval between occurrences of the problem; the redundancy of the affected component within the system; the criticality of the component to the system; the resources required to perform the maintenance necessary to correct the problem; and the expected component or system downtime.

2.4 ANALYSIS OF COMPONENT MAINTENANCE PROBLEMS AND DEFINITION OF SOLUTIONS

Once the component maintenance problems and their causes were identified, solutions were sought by examining each problem in relation to the extent to which it is recognized and its susceptibility to established types of corrective action. These analysis criteria are expressed in the following questions:

- Is the problem known to the Navy technical community and has a solution been proposed or established?
- Will a design change reduce or eliminate the problem?
- Is the problem PMS-related? Can the problem be reduced or eliminated by changes to PMS? (These changes might include adding or deleting requirements, changing requirement periodicity, or developing material condition assessment tests and procedures.)

- Can the problem be reduced or eliminated by improving the system's Integrated Logistics Support (ILS)?
- Can the problem be reduced or eliminated by improving Ship's Force, Intermediate Maintenance Activity (IMA), or depot-level capabilities?
- Can the problem be reduced or eliminated by periodically performing restorative maintenance? Should this be accomplished at a Selected Restricted Availability (SRA) by Ship's Force, IMA, or depot-level facilities?
- Is the run-to-failure concept a viable maintenance strategy for the associated equipment?

An affirmative answer to any question resulted in analysis of the effects of the solution and in an estimate, when possible, of the cost to implement the solution. A negative answer prompted the analyst to go to the next question. After all the questions were answered, the alternative near-term and long-term solutions were evaluated and the most acceptable alternatives defined and documented as recommendations. "Near-term" recommended solutions, as used in this report, are those that should be, and are likely to be, accomplished before completion of the initial FF-1052 Class Baseline Overhauls. "Long-term" recommended solutions are those that are not likely to be accomplished until some or all of the FF-1052 Class Baseline Overhauls have been completed.

The historical overhaul experience for all installations of each selected component was then correlated with the recommended problem solutions. An evaluation was made to establish the Baseline Overhaul requirements for each selected component.

CHAPTER THREE

RESULTS

3.1 OVERVIEW

This chapter presents the results of the analysis of maintenance experience for the ASROC Missile Heating and Cooling System and the Radar-Sonar Electronic Fresh Water Cooling System used on FF-1052 Class ships. Since some components are common to both systems, the data on maintenance burden are not separated by system. Data screening resulted in the identification of 11 system components as the major maintenance burden contributors. Table 3-1 summarizes the data for these components. Twenty-three parts within 9 of the 11 components were identified by the screening process as items requiring analysis. Usage data for these parts are presented in Appendix B. Data for the other 2 selected components (fluid cooler, APL 030010190, and motor, APL 174752409) did not indicate any part whose usage was sufficient to warrant detailed analysis.

Two parts with a replacement cost exceeding $1000 were replaced during the data period. Three replacements of the impeller (NIIN 917-3607) on 2 ships were for the ASROC Heating and Cooling Pump (APL 016150572) and 1 replacement of the rotor (NIIN 018-2341) for the ASROC Heating and Cooling Pump Motor (APL 174752347). Usage data for these 2 parts did not indicate a recurring maintenance problem; the failures therefore were considered random.

The combined maintenance burden reported against the two systems, as determined from MDS data and CASREPTs, is low relative to other ship systems that have been analyzed. Table 3-2 is a listing of the average system maintenance burdens for a number of typical FF-1052 Class systems that have been analyzed. No major maintenance-related problems were identified to either system; however, requirements for Baseline Overhaul, intracycle maintenance, and follow-on ROH repairs and overhauls will be discussed in subsequent sections of this report.

3.2 MDS HISTORY

Analysis of the MDS data shows that the reported man-hour burdens for individual selected components of the ASROC Missile Heating and Cooling

Table 3-1. MAINTENANCE BURDEN SUMMARY DATA FOR FF-1052 CLASS ASROC MISSILE HEATING AND COOLING SYSTEM AND RADAR-SONAR ELECTRONIC FRESH WATER COOLING SYSTEM

APL	Nomenclature	Applicable Ships	Equipments per Ship	Total Equipment Population	Ship Operating Time (Ship-Years)	Ships Reported	JCNs	Ship's Force Man-Hours	IMA Man-Hours	Total Man-Hours	Parts Cost (Dollars)	Average Man-Hours/ Equipment/ Operating Year
016020860	Pump CTFGL	26	2	52	132	24	88	1115	396	1511	5602	5.7
016150572	Pump CTFGL	26	2	52	132	22	133	1213	521	1734	10,246	6.6
016210231	Pump CTFGL	20	2	40	68	17	67	301	385	686	5653	5.0
016210232	Pump CTFGL	20	2	40	68	15	56	341	151	492	3394	3.6
030010190	Cooler - FL	46	1	46	200	19	58	475	322	797	1251	4.0
030010191	Cooler - FL	46	1	46	200	20	48	338	565	903	610	4.5
030010195	Cooler - FL	46	1	46	200	24	73	473	600	1073	1598	5.4
080150006	Demineralizer	26	1	26	132	11	42	163	43	206	587	1.6
081080004	Demineralizer	20	1	20	68	8	32	96	0	96	1250	1.4
174752347	Motor - AC	26	2	52	132	11	30	504	311	815	2624	3.1
174752409	Motor - AC	20	4	80	68	6	7	54	68	122	547	0.4
TOTALS							634	5073	3362	8435	33,362	
TOTALS REPORTED FOR ALL SYSTEM APLs							958	7124	4859	11,983	43,354	59.9*
PERCENT OF TOTAL REPORTED ACCOUNTED FOR BY SELECTED APLs							66	71	69	70	77	

*Average system man-hour burden per ship per operating year.

Table 3-2. MAN-HOUR BURDEN SUMMARY FOR SELECTED FF-1052 CLASS SHIP SYSTEMS

System	Ship Operating Year During Data Period	Total Burden (SF and IMA Man-Hours)	Average Man-Hours per Ship Operating Year
Ship's Stores Refrigeration	185.9	5,637	30.3
Prairie/Masker	185.9	7,612	40.9
Missile Heating & Cooling and Electronic Cooling Systems (Combined)*	200.0	11,983	59.9
Combustion Air**	151.4	14,063	92.9
Chilled Water Air Conditioning	185.9	24,297	130.7
Ship's Service Turbo Generator	185.9	27,889	150.0
Ship's Service Diesel Generator	185.9	28,257	152.0
Distilling Plant	151.4	36,176	238.9
Feed and Condensate**	151.4	38,728	255.8
Propulsion Boiler**	151.4	104,760	691.9

*Combined figures for both systems.
**Major burden-consuming components only.

System and the Radar-Sonar Electronic Fresh Water Cooling System are not significant and that, for both systems combined, the component man-hour and parts-cost burdens averaged only 59.9 man-hours and approximately $217, respectively, per operating year. Table 3-1 presents maintenance-burden summary data for the major burden-producing components of the system. The 11 components listed in the table accounted for 70 percent of the total maintenance man-hours and 77 percent of the total parts costs reported against both systems.

A review of the part replacements reported during the data period (see Appendix B, Table B-1) shows that, when mechanical seals and mixed-bed and oxygen cartridges are excluded, the overall number of replacements of maintenance-related parts -- i.e., wearing rings, shaft sleeves, bearings, and anodes -- is small. The data for these parts neither reflect high usage rates nor indicate a maintenance problem.

The three most frequently replaced parts are the mechanical seals, mixed-bed cartridges, and oxygen cartridges. The mechanical seals are checked monthly in accordance with PMS-required Maintenance Requirement Cards (MRCs) A9-U816-M, CO-P020-M, and 95-4285-M. The mixed-bed and oxygen cartridges of the Demineralizer are constantly checked and are replaced whenever water resistivity drops below 1 megohm for inlet purity or 5 megohms for outlet purity and water oxygen content rises above 0.1 ppm. These three parts are normally considered consumables that will be replaced periodically as a routine maintenance action; their replacement is not generally related to major corrective maintenance of systems or components.

A problem in logistic support of the mixed-bed cartridge, NSN 9C4610-00-712-9394 -- used only in the Radar-Sonar Electronic Fresh Water Cooling System -- was identified during review of the parts usage data and confirmed during ship surveys. As shown in Table B-1, Appendix B, 20 of these cartridges were replaced on Demineralizer APL 080150006 and 26 on Demineralizer APL 081080004.

Review of the Demineralizer APLs, both dated 1 March 1976, disclosed that they list 2 each of the oxygen cartridges, NSN 9C4610-00-776-0688, as allowable shipboard spares but show no spares for the mixed-bed cartridge. Naval Ships Technical Manuals 389-0424 for APL 080150006 and 0948-038-1010 for APL 081080004 indicate that the mixed-bed cartridge should be replaced whenever the water resistivity of the demineralizer drops below the acceptable level of 1 megohom for inlet purity or 5 megohms for outlet purity. They also provide that the oxygen cartridge should be replaced whenever the oxygen content of the water rises above 0.1 ppm, as indicated by a standard oxygen test; however, regardless of whether the oxygen test is performed, the oxygen cartridge should be replaced whenever the mixed-bed cartridge is replaced. In view of this provision for concurrent replacement, ARINC Research recommends that the mixed-bed cartridge, NSN 9C4610-00-712-9394, be added to the ship's allowance list and stocked as an onboard spare in quantities of 2 each for APL 080150006 on ship classes FF-1052 through 1077 and APL 081080004 for ship classes FF-1078 through 1097.

3.3 CASREPT HISTORY

CASREPT data for the FF-1052 Class -- summarized in Appendix C -- show a total of 13 CASREPTs submitted against the ASROC Missile Heating and Cooling System and the Radar-Sonar Electronic Fresh Water Cooling System during the period 1 July 1973 through 30 June 1976. This total represents a rate of approximately 0.1 reports per ship operating year.

As indicated in Table C-1 of Appendix C, the 13 reports were distributed among 9 system components, with no more than 3 against any one component. Thus, no single component of the systems has been the source of continually recurring CASREPTs. Of the 13 CASREPTs, 10 were at the C-2 level, indicating only minor degradation, and 3 were C-3 level -- i.e., failures involving

major degradation but loss of only one mission. The absence of C-4 level CASREPTs -- those reporting major degradation and loss of more than one mission -- indicates that, although the reported failures did reduce system capability, only three failures caused significant degradation of the systems.

The summary of CASREPT correction time in Table C-2, Appendix C, shows that downtime resulting from CASREPT-documented failures was exceptionally low. Downtime classified as Not Operationally Ready, Supply (NORS) totalled 163 days -- an average of less than 2 days per ship per year. Total downtime for NORS and maintenance combined was 395 days, or less than 3 days per ship per year.

The conclusions drawn from the analysis of CASREPT data are (1) that the ASROC Missile Heating and Cooling System and the Radar-Sonar Electronic Fresh Water Cooling System experienced no failures that caused the systems to be completely inoperative; and (2) that downtime resulting from the reported failures was minimal.

3.4 BASELINE OVERHAUL REQUIREMENTS

The baseline overhaul concept in the DDEOC Program is designed to ensure that ships entering an extended operating cycle are in a state of material condition readiness such that there is a high probability of operation without major restorative maintenance throughout the cycle. In keeping with this philosophy, ARINC Research recommends that the heat exchangers of the ASROC Missile Heating and Cooling System and the Radar-Sonar Electronic Fresh Water Cooling System be hydrostatically tested and that the systems be thoroughly cleaned and flushed during BOH. Determination of the need for pump and motor overhauls or repairs should be based on the results of pre-BOH tests and inspections. Table 3-3 presents specific recommendations for Baseline Overhaul.

3.5 INTRACYCLE AND FOLLOW-ON ROH MAINTENANCE REQUIREMENTS

Requirements for routine intracycle maintenance are, for the most part, adequately addressed by the existing PMS and easily accomplished by Ship's Force.

Required corrective maintenance during the extended operating cycle should also be performed primarily by Ship's Force, assisted by an IMA as necessary. Follow-on ROH maintenance requirements should be identified by pre-ROH test and inspection as well as ship's CSMP.

Table 3-3. BASELINE OVERHAUL REQUIREMENTS

Component/Equipment	Recommendation
ASROC Heating and Cooling Pumps	Perform overhaul or repairs indicated necessary by Pre-Overhaul, Test, and Inspection (POT&I) or ship's CSMP.
ASROC Heating and Cooling Pump Motors	Perform overhaul or repairs indicated necessary by POT&I or ship's CSMP.
ASROC Heat Exchangers	Perform hydrostatic test and accomplish repairs as necessary.
ASROC Heating and Cooling System	Clean, flush, and test.
Radar-Sonar Cooling Water Pumps	Perform overhaul or repairs indicated necessary by POT&I or ship's CSMP.
Radar-Sonar Cooling Water Pump Motors	Perform overhaul or repairs indicated necessary by POT&I or ship's CSMP.
Radar-Sonar Heat Exchangers	Perform hydrostatic test and accomplish repairs as necessary.
Radar-Sonar Electronic Cooling System	Clean, flush, and test.

3.6 MATERIAL CONDITION ASSESSMENT

Preventive maintenance requirements for the pumps of the ASROC Missile Heating and Cooling System and the Radar-Sonar Electronics Fresh Water Cooling System provide for the checking of leakage from the mechanical seals on a monthly basis and replacement of the seals when leakage becomes excessive. Further, when the pumps are disassembled for mechanical seal replacement, the pump internals are to be inspected and clearances measured. Repairs are to be accomplished while the pump is disassembled for seal replacement. MRCs A3-D41Z-N, 49-T186-C, and 22-B18-C further require that the pumps be opened and inspected once during each 36-month cycle and repairs accomplished as necessary.

Ship survey results indicate that, when the pumps are open for seal replacement, wearing rings are frequently replaced for convenience rather than poor performance or excessive wear. Recent studies by the Naval Systems Engineering Center, Philadelphia Division, [NAVSEC (PHILADIV)] -- described in NAVSEC (PHILADIV) Letter to NAVSEA (PMS-306), Serial #153, 16 March 1976 -- have shown that the current practice of replacing wearing rings when the clearance exceeds twice the maximum design value is too conservative, since centrifugal pumps can perform, with only minimal degradation, with wearing ring clearances up to three times the design maximum. Discussions with maintenance and technical personnel disclosed a widely held opinion that "open and inspect" maintenance actions based

on calendar time are ill advised and lead to more frequent pump overhauls than would normally be required if the "open and inspect" action were triggered by some externally measured parameter that was indicative of degraded performance and a clear need for pump repairs.

The pumps installed in the ASROC Missile Heating and Cooling System and the Radar-Sonar Electronic Fresh Water Cooling System have not been a significant maintenance burden. Each system has total redundancy that either of the pumps will accommodate the total system demand if the second pump fails. Ship's Force personnel are normally able to accomplish corrective maintenance on the pumps without outside assistance. Therefore, a "run-to-failure" maintenance strategy would involve little risk. "Run-to-failure", as used in this report, means the policy of performing maintenance when the equipment shows evidence of needing maintenance. In the pumps, examples of such evidence might be vibration, noise, hot bearings, or low discharge pressure causing deficient system performance.

ARINC Research recommends that the current PMS practice of opening and inspecting the pumps once during each 36-month cycle (MRCs A3-D41Z-N, 49-T186-C and 22-B18D-C) be discontinued and that a "run-to-failure" maintenance strategy be adopted during the interval between BOH and the follow-on ROH. These pumps should be identified as possible candidates for the development of material condition assessment criteria and performance monitoring techniques. When developed, these criteria and techniques will indicate the need for maintenance prior to failure and will permit a shift in pump maintenance strategy from "run-to-failure" to "on-condition" maintenance for the ASROC Missile Heating and Cooling System and the Radar-Sonar Electronic Fresh Water Cooling System.

CHAPTER FOUR

CONCLUSIONS AND RECOMMENDATIONS

4.1 CONCLUSIONS

The following are the major findings and conclusions resulting from this Review of Experience:

- The FF-1052 Class ASROC Missile Heating and Cooling System and the Radar-Sonar Electronic Fresh Water Cooling System have not been major contributors to the overall ship maintenance burden.
- Major restorative maintenance should not be required on these systems during the extended operating cycle.
- Reduced system capability has not been frequent or severe; down-time resulting from the few reported failures has not been significant.
- A "run-to-failure" maintenance strategy for system pumps during the period between BOH and ROH appears feasible.
- Past practice has generally been to overhaul the heat exchangers and clean, flush, and test the complete systems during each Regular Overhaul (ROH). Additional overhauls or repairs to pumps, motors, and other system components have been based on results of pre-ROH tests and inspections or on the current ship's maintenance project (CSMP).
- The mixed-bed cartridge, NSN 9C4610-00-712-9394, is not listed on Demineralizer APLs 080150006 and 081080004 as an allowed on-board spare.

4.2 RECOMMENDATIONS

The following recommendations are presented on the basis of the analyses, findings, and conclusions:

- Cyclic open-and-inspect PMS requirements for system pumps should be deleted.
- Adopt a "run-to-failure" maintenance strategy for system pumps during the period between BOH and ROH.

- Material Condition Assessment criteria and performance monitoring techniques should be developed for the pumps of the ASROC Missile Heating and Cooling System and Radar-Sonar Electronic Fresh Water Cooling System to permit a shift from "run-to-failure" maintenance to "on-condition" maintenance.
- The heat exchangers of the ASROC Missile Heating and Cooling System and the Radar-Sonar Fresh Water Cooling System should be overhauled and the entire systems cleaned, flushed, and tested during Baseline Overhaul (BOH). Determination of the need for pump and motor overhauls or repairs should be based on the results of pre-BOH tests and inspections and ship's CSMP.
- Ship's Force personnel, supported by an Intermediate Maintenance Activity as necessary, should perform all required corrective maintenance during the operating cycle. System repairs required during the follow-on ROH should be determined on the basis of pre-ROH inspections and tests and ship's CSMP.
- Ships Allowance List should be updated to include the Mixed-Bed Cartridge, NSN 9C4610-00-712-9394, as an allowed on-board spare -- 2 each for component APL 080150006 for ship classes FF-1052 through 1077 and 2 each for component APL 081080004 for ship classes FF-1078 through 1097.

A detailed listing of PMS changes that will be required to implement the recommendations is presented in Appendix D. Proposed action items based on the Review of Experience are detailed in Appendix E.

SOURCES OF INFORMATION

The specific sources of information used as the basis for the Review of Experience of the ASROC Missile Heating and Cooling System and the Radar-Sonar Electronic Fresh Water Cooling System are listed below:

1. Generation IV MDS Part and Maintenance Data for DE/FF-1052 Class, for period 1 January 1970 through 31 October 1976.
2. CASREPTs for DE/FF-1052 Class for period 1 July 1973 through 30 June 1976.
3. Material Maintenance Management (3M) Manual: OPNAVINST 4790.4, Volumes I, II, and III (dated June 1973).
4. Maintenance Index Pages (MIPs) for the ASROC Missile Heating and Cooling System and the Radar-Sonar Electronic Fresh Water Cooling System.
5. Maintenance Requirement Cards (MRCs) as listed on the MIPs for the ASROC Missile Heating and Cooling System and the Radar-Sonar Electronic Fresh Water Cooling System.
6. Type Commander's Coordinated Shipboard Allowance List (COSAL), SURFLANT (dated 19 May 1975) and SURFPAC (dated 19 August 1975).
7. FF-1052 Class Ship Alteration and Repair Plans (SARPs).
8. Technical Manual, ASROC Heating and Cooling System: NAVSHIPS 0997-000-4010 (June 1972).
9. Technical Manual, ASROC Heating and Cooling Circulating Pump (Buffalo Type 2x3 CCO): NAVSHIPS 0947-071-8010 (March 1969).
10. Technical Manual, ASROC Heater (Aqua-Chem Model F-38C): NAVSHIPS 0949-046-2010 (October 1967).
11. Technical Manual, ASROC Heating Circulating & Electronic Cooling Water Pumps (Fairbanks-Morse 1-1/2 Figure 5554X Horizontal, Close-Coupled, Centrifugal): NAVSHIPS 0947-091-1010 (January 1968).
12. Technical Manual, Radar-Sonar Cooling Pump: NAVSHIPS 0947-067-5010.
13. Technical Manual, Demineralizer for Radar-Sonar Cooling System and NTDS Cooling System (Barnstead Model PL-1A): NAVSHIPS 389-0424 (October 1964).

14. Technical Manual, Demineralization System (Environmental Control Systems Model C-501F): NAVSHIPS 0948-038-1010 (May 1968).

15. Technical Manual, Radar-Sonar Cooler (SW/FW) (Aqua-Chem, Inc. Model H-54A) NAVSHIPS 0948-041-4010 (September 1967).

16. ARINC Research visit to the USS MILLER (FF-1091), USS TRUETT (FF-1095), USS PUGET SOUND (AD-38), and SURFLANT, Norfolk, Virginia, 2-4 August 1977.

17. Letter to NAVSEA (PMS-306) from NAVSEC (PHILADIV): 6723D:JLB: ktr; 9470 (B-1158); Ser 153, 16 March 1976 -- Subj: Performance Test Analysis for Centrifugal Pump; report of (plus enclosures).

APPENDIX A

MAJOR SYSTEM COMPONENTS

Tables A-1 and A-2 of this appendix present listings of the major components of the ASROC Missile Heating and Cooling System and the Radar-Sonar Electronic Fresh Water Cooling System, respectively. The data presented in these tables were derived from the Type Commander's COSAL and include the nomenclature of the equipment, associated APL number, quantity installed per ship, applicable hulls, and associated technical manuals. General-purpose valves, piping, strainers, and gages that comprise the remainder of the systems have been intentionally omitted from the tables.

Table A-1. MAJOR COMPONENTS OF THE FF-1052 CLASS ASROC MISSILE HEATING AND COOLING SYSTEM

Nomenclature	APL Number	Quantity per Ship	Applicable Hulls	Technical Manual
Pump - CTFGL 80 GPM	016150572	2	FFs-1052-1077	0947-071-8010
Pump - CTFGL 80 GPM	016210231	2	FFs-1078-1097	0947-091-1010
Motor - AC 20 HP	174752347	2	FFs-1052-1077	0947-071-8010
Motor - AC 20 HP	174752409	2	FFs-1078-1097	0947-091-1010
Starter Motor	151208033	2	FFs-1052-1056, 1058-1062,1064, 1066-1068,1070-1072,1074-1097	0947-071-8010
Starter Motor	151405972	2	FFs-1057,1063, 1065,1069, and 1073	-
Cooler - Fluid	030010191	1	FFs-1052-1097	0997-000-4010
Heater - STM HTG	070010099	1	FFs-1052-1097 (Note: 2 each for FFs-1056, 1059,1061,1068, 1072,1075, and 1077	0948-046-2010
Tank - Expansion	NA	1	FFs-1052-1097	0997-000-4010

Table A-2. MAJOR COMPONENTS OF THE FF-1052 CLASS RADAR-SONAR ELECTRONIC FRESH WATER COOLING SYSTEM

Nomenclature	APL Number	Quantity per Ship	Applicable Hulls	Technical Manual
Pump - CTFGL 130 GPM	016020860	2	FFs-1052-1077	0947-067-5010
Pump - CTFGL 130 GPM	016210232	2	FFs-1078-1097	0947-091-1010
Motor - AC 20 HP	174752443	2	FFs-1052-1077	0947-067-5010
Motor - AC 20 HP	174752409	2	FFs-1078-1097	0947-091-1010
Starter Motor	151207598	2	FFs-1052-1056, 1058-1062,1064, 1066-1068,1070-1072,1074-1077	0947-067-5010
Starter Motor	151406025	2	FFs-1057,1063, 1065,1069, and 1073	-
Cooler - 17.3 Sq. Ft.	030010190	1	FFs-1052-1097	-
Cooler - 105 Sq. Ft.	030010195	1	FFs-1052-1097	0947-041-4010
Demineralizer - FW	080150006	1	FFs-1052-1077	389-0424
Demineralizer - FW	081080004	1	FFs-1078-1097	0948-038-1010

APPENDIX B

MDS PARTS USAGE SUMMARY

Table B-1 presents a listing of the significant parts replaced in the ASROC Missile Heating and Cooling System and the Radar-Sonar Electronic Fresh Water Cooling System. The list was derived from screening MDS data in accordance with the procedures described in Chapter Two. Included in Table B-1 are the average cost per unit; quantity per equipment; total part population; number of parts replaced; the ratio of parts replaced to total population; and the number of ships reporting replacements.

Table B-1. SIGNIFICANT PARTS USAGE FOR THE FF-1052 CLASS ASROC MISSILE HEATING AND COOLING SYSTEM AND RADAR-SONAR ELECTRONIC FRESH WATER COOLING SYSTEM

Part Identification		Average Cost Per Unit (Dollars)	Quantity per Component	Replacement Data			
NIIN	Nomenclature			Total Part Population	Number Replaced	Ratio (×100) of Parts Replaced to Total Population	Number of Ships Reported
	PUMP-CTFGL APL 016020860						
947-5114	Seal-Mechanical	54	1	52	53	101	16
	PUMP-CTFGL APL 016150572						
915-4642	Sleeve-Shaft	52	1	52	9	17	5
915-4661	Ring-Wrg Imp	50	1	52	11	21	6
915-4683	Ring-Wrg CSG	6	1	52	9	17	5
915-4731	Ring-Wrg CSG	6	1	52	9	17	5
916-7081	Ring-Wrg Imp	84	1	52	12	23	7
916-7087	Seal-Mechanical	53	1	52	71	137	16
917-3607	Impeller	1008	1	52	3	6	2
	PUMP-CTFGL APL 016210231						
127-2662	Ring-Wgr Imp Os	14	2	80	15	19	7
127-2663	Ring-Wrg Csg Us	95	2	80	14	18	5
128-9962	Seal-Mechanical	113	1	40	22	55	9
	PUMP-CTFGL APL 016210232						
121-6059	Seal-Mechanical	60	1	40	29	73	12
127-2662	Ring-Wrg Imp Os	14	2	80	13	16	7
127-2663	Ring-Wrg Csg Us	95	2	80	8	10	5
	COOLER APL 030010191						
582-2012	Anode-CRSN PVNTV	2	8	368	40	11	18
	COOLER APL 030010195						
582-2012	Anode-CRSN PVNTV	2	8	368	215	58	18
	DEMINERALIZER APL 080150006						
712-9394	Cartridge-Mixed-Bed	17	1	26	20	77	14
776-0688	Cartridge-02	17	1	26	22	85	15
	DEMINERALIZER APL 081080004						
712-9394	Cartridge-Mixed Bed	17	1	20	26	130	14
776-0688	Cartridge-02	17	1	20	23	115	15
	MOTOR-AC APL 174752347						
018-2341	Rotor Assy	1200	1	52	1	2	1
991-0940	Bearing-B-Ann	21	1	52	10	19	9
992-1008	Bearing-B-Ann	51	1	52	13	25	8

APPENDIX C

CASREPT SUMMARY ANALYSIS

CASREPTs for the FF-1052 Class covering the period 1 July 1973 through 30 June 1976 were analyzed to determine the types of failures experienced by the ASROC Missile Heating and Cooling System and the Radar-Sonar Electronic Fresh Water Cooling System. Thirteen CASREPTs were reviewed. Table C-1 shows the number and percentage of the total CASREPTs reported against each system component.

To determine the rate of CASREPT submissions against the systems, the total number of CASREPTs were divided by the total ship operating years covered by the CASREPT data period. Thus,

$$\frac{\text{CASREPTs}}{\text{Ship Operating Years}} = \frac{13}{114.4} = 0.1 \text{ CASREPTs per Ship Operating Year}$$

Table C-2 presents information on the time required to correct system CASREPTs. Correction time was divided into maintenance time and time awaiting parts. The data indicated that the systems were reported as awaiting parts -- i.e., Not Operationally Ready, Supply (NORS) -- for 163 days, or approximately 41 percent of the total CASREPT time.

Thus, the average number of downtime days, as reported in CASREPTs, is:

$$\text{NORS Days} = \frac{163 \text{ Days}}{46 \text{ Ships}} = 3.5 \text{ Days per Ship}$$

$$\text{Total Downtime Days} = \frac{395 \text{ Days}}{46 \text{ Ships}} = 8.6 \text{ Days per Ship}$$

The resulting annual downtime is:

$$\text{NORS Days} = \frac{3.5 \text{ Days per Ship}}{36 \text{ Operating Months}} \times 12 \text{ Months per Year}$$

$$= 1.2 \text{ Supply Downtime Days per Ship per Year}$$

$$\text{Total Downtime} = \frac{8.6 \text{ Days per Ship}}{36 \text{ Operating Months}} \times 12 \text{ Months per Year}$$

$$= 2.9 \text{ Total Downtime Days per Ship per Year}$$

Table C-1. CASREPT SUMMARY FOR COMPONENTS OF FF-1052 CLASS ASROC MISSILE HEATING AND COOLING SYSTEM AND RADAR-SONAR ELECTRONIC FRESH WATER COOLING SYSTEM

Equipment/Components and Failure Modes	Number of Failure Modes Reported	CASREPTs Reported		Number of Ships Reporting
		Number	Percent of Total	
PUMP - ASROC HEATING & COOLING		1	8	1
Impeller/Casing Wear Rings				
Improper Installation	1			1
COOLER - ASROC HEATING & COOLING		1	8	1
Leaking	1			1
COOLER - RADAR-SONAR COOLING		1	8	1
Leaking	1			1
MOTOR - ASROC HEATING & COOLING		3	23	2
Windings				
Burned Out	1			1
Bearing Failure				
Machine Room Flooded	2			1
MOTOR - RADAR-SONAR COOLING		2	15	2
Windings				
Burned Out	1			1
Zero Grounding	1			1
STRAINER - ASROC HEATING & COOLING AND RADAR-SONAR COOLING		2	15	1
Leaking	1			1
Defective	1			1
VALVE-REDUCER (BOTH SYSTEMS)		1	8	1
Normal Wear	1			1
VALVE-RELIEF (BOTH SYSTEMS)		1	8	1
Normal Wear	1			1
HOSE ASSY - MISC (BOTH SYSTEMS		1	7	1
Cracked Lining - Normal Deterioration	1			1
TOTAL		13	100	

Table C-2. CASREPT CORRECTION TIME FOR COMPONENTS OF FF-1052 CLASS ASROC MISSILE HEATING AND COOLING SYSTEM AND RADAR-SONAR ELECTRONIC FRESH WATER COOLING SYSTEM

APL	Nomenclature	Days Down Total	Days Down Maintenance	Days Down Supply	Number CASREPTs	Average Days Down per CASREPT	Average Days NORS per CASREPT	Percent Down Due to Maintenance	Percent Down Supply
016150572	Pump-CTFGL	43	43	0	1	43	0	100	0
030010191	Cooler - FL	5	0	5	1	5	5	0	100
030010195	Cooler - FL	33	0	33	1	33	33	0	100
174752347	Motor - AC	74	8	66	3	25	22	11	89
174752443	Motor - AC	36	36	0	2	18	0	100	0
750260103	Strainer - Y	92	63	29	2	46	15	68	32
882094211	Valve - Reducer	22	0	22	1	22	22	0	100
883113886	Valve - Relief	10	2	8	1	10	8	20	80
2-480020013	Hose Assy - Misc	80	80	0	1	80	0	100	0
	TOTAL	395	232	163	13				
				AVERAGE FOR SYSTEMS		30.4	12.5	59	41

APPENDIX D

MRC EVALUATION

The DDEOC MRC Evaluation table in this appendix specifies the Maintenance Index Pages (MIP) applicable to the ASROC Missile Heating and Cooling System and the Radar-Sonar Electronic Fresh Water Cooling System, and lists the Maintenance Requirements Cards (MRCs) that should be modified or deleted to implement the recommendations in Chapter Four.

Supplementary information concerning the column headings of the DDEOC MRC Evaluation form is provided below:

- MRC Title - Title of MRC, applicable MIP page numbers, and description of maintenance specified by MRC
- Responsibility - Organizations responsible for change
- Man-Hours - Personnel time burden allotted to complete maintenance action
- Frequency - When the MRC maintenance action is to be performed, e.g., D = Daily, W = Weekly, M = Monthly, Q = Quarterly, C = Once every cycle, R = As required
- Type - Perform maintenance (P), or survey material condition of component (S)
- Who Performs Test - Organizations responsible for performing maintenance action or test -- i.e., tender, DDEOC Site Team, or Ship's Force personnel
- Data - Indicates whether data are recorded during performance of maintenance action

MRC TITLE	MRC NUMBER	RESPONSIBILITY		CURRENT STATUS			MAN-HOURS	
		NAVSEA	DDEOC	OLD WITH NO CHANGE	OLD WITH REVISION	NEW	PRE-DDEOC M/H	POST-DDEOC M/H
ELECTRIC DRIVEN FRESH WATER PUMP - MIP A-40/182-A3								
1. Inspect internal parts.	A3-D41Z-N		X		X		8.2	8.2
ASROC HEATING AND COOLING FLUID CIRCULATING PUMP - MIP A-39/17-49								
1. Inspect internal parts for wear; measure clearances. Renew mechanical seal.	49-T186-C		X		X		8.0	8.0
ELECTRIC DRIVEN FRESH WATER PUMP - MIP A-40/153-22								
1. Inspect internal parts; renew mechanical seal.	22-B18D-C		X		X		8.0	8.0

*P = PERFORM MAINTENANCE; S = SURVEY INSPECTION

2 1

SHIP CLASS: FF
SMA NO: 218-
SYSTEM: ASRO
Cooling; Radi
Fresh Water C

DDEOC MRC EVALUATION

CURRENT STATUS			MAN-HOURS		FREQUENCY		TYPE*	WHO PERFORMS TEST			WHERE PERFORMED	DATA	REMARKS
OLD WITH NO CHANGE	OLD WITH REVISION	NEW	PRE-DDEOC M/H	POST-DDEOC M/H	PRE-DDEOC	POST-DDEOC	P-PERF. S-SURV.	TENDER	DDEOC	SHIP	I-IN PORT S-AT SEA	YES NO	
	X		8.2	8.2	C		P,S			X	I	Yes	Delete requirements.
	X		8.0	8.0	C		P,S			X	I	Yes	Delete requirements.
	X		8.0	8.0	C		P,S			X	I	Yes	Delete requirements.

SHIP CLASS: FF-1052

SMA NO: 218-728

SYSTEM: ASROC Missile Heating & Cooling; Radar-Sonar Electronic Fresh Water Cooling

EST	WHERE PERFORMED	DATA	REMARKS
SHIP	I-IN PORT S-AT SEA	YES NO	
X	I	Yes	Delete requirements.
X	I	Yes	Delete requirements.
X	I	Yes	Delete requirements.

APPENDIX E

DDEOC ACTION TABLE

The DDEOC Action Table summarizes action information for each of the recommendations discussed in this report.

DDEOC AC

1. ACTION ITEM * a. NO.	1. ACTION ITEM * b. TITLE	2. DDEOC EVALUATION **	3. ACTION ITEM DESCRIPTION	4. REPOR REFERE (PARA
1.	Reliability and Maintainability Improvements		Develop material condition assessment criteria and performance monitoring techniques for the ASROC Missile Heating and Cooling and the Radar-Sonar Electronic Fresh Water Cooling pumps to permit a shift from "run-to-failure" maintenance strategy to "on-condition" maintenance for these equipments.	3.(
2.	PMS Changes		Delete MRCs A3-D41Z-N, 49-T186-C, and 22-B18D-C.	3.(
3.	Baseline Overhaul Requirements		Overhaul the Missile Heating and Cooling System and the Electronic Fresh Water Cooling System in accordance with Table 3-3.	3.4
4.	Intracycle Maintenance Requirements		Ship's Force accomplish all required intracycle corrective maintenance supported by IMA as necessary.	3.5
5.	Follow-ROH Requirements		Accomplish system repairs as necessary based on results of pre-ROH inspection and tests and ship's CSMP.	3.5
6.	Logistic Support Requirements		Add mixed-bed cartridge, NSN 9C4610-00-712-9394, to ships allowance list and stock as an onboard spare (2 each on APL 080150006 for FF-1052-1077 and 2 each on APL 081080004 for FF-1078-1097).	3.5

* NOTE 1: DEVELOPING ACTIVITY FILL IN THE FOLLOWING BLOCKS: 1a, b; 3; 4; 5 (IF KNOWN); 6a, IF REQUIRED FOR CO

** NOTE 2: DDEOC EVALUATION – APPROVED, FURTHER STUDY REQ'D, ETC.

† NOTE 3: RESPONSIBILITY – ACTIVITY RESPONSIBLE FOR TAKING THE ACTION.

2 1

SHIP CLAS
SMA NO:
SYSTEM:
Electro

DDEOC ACTION TABLE

ACTION ITEM DESCRIPTION	4. REPORT REFERENCE (PARA.)	5. RESPONSIBILITY †	6. SCHEDULING DATES a. REQD.	b. START	c. COMP.	7. REMARKS, FUNDING IMPLICATIONS, ETC.	8
rial condition assessment performance monitoring or the ASROC Missile Heating and the Radar-Sonar Electronic Cooling pumps to permit a "run-to-failure" maintenance "on-condition" maintenance for ents.	3.6	NAVSEA					
A3-D41Z-N, 49-T186-C, and	3.6	NAVSEA					
Missile Heating and Cooling the Electronic Fresh Water tem in accordance with	3.4	TYCOM					
accomplish all required corrective maintenance IMA as necessary.	3.5	TYCOM					
system repairs as necessary sults of pre-ROH inspection and hip's CSMP.	3.5	TYCOM					
ed cartridge, NSN 9C4610-00- ships allowance list and onboard spare (2 each on 06 for FF-1052-1077 and 2 081080004 for FF-1078-1097).	3.2	NAVSEA					

b; 3; 4; 5 (IF KNOWN); 6a, IF REQUIRED FOR CONTINUATION OF DEVELOPING ACTIVITY TASK; 7, AS NECESSARY.
TC.
ACTION.

SHIP CLASS: FF-1052

SMA NO: 218-728

SYSTEM: Missile Heating & Cooling; Electronic Fresh Water Cooling

EDULING DATES		7. REMARKS, FUNDING IMPLICATIONS, ETC.	8. ACTUAL ACTION TAKEN
START	c. COMP.		

VITY TASK; 7, AS NECESSARY.